

Hartebeesthoek Radio Astronomy Observatory (HartRAO)

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Abstract HartRAO provides the only fiducial geodetic site in Africa and participates in global networks for VLBI, GNSS, SLR, and DORIS. This report provides an overview of geodetic VLBI activities at HartRAO during 2014, including the 15-m radio telescope taking over from the 26-m for the majority of sessions, progress with the VGOS project, and preparations for hosting the 9th IVS General Meeting in 2016.

1 Geodetic VLBI at HartRAO

Hartebeesthoek is located 65 km northwest of Johannesburg, just inside the provincial boundary of Gauteng, South Africa. HartRAO is located 32 km away from the nearest town, Krugersdorp. The telescopes are situated in an isolated valley which affords protection from terrestrial radio frequency interference. HartRAO currently operates both a 15-m and a 26-m radio telescope. The 26 m is an equatorially mounted Cassegrain radio telescope built by Blaw Knox in 1961. The telescope was part of the NASA deep space tracking network until 1974 when the facility was converted to an astronomical observatory. The 15 m is an alt-az radio telescope built as a Square Kilometre Array (SKA) prototype during 2007 and converted to an operational geodetic VLBI antenna during 2012. The telescopes are co-located with an ILSR SLR station (MOBLAS-6), an IGS GNSS station (HRAO), a seismic vault, and an IDS DORIS station (HBMB) at the

HartRAO

HartRAO Network Station

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adjoining South African National Space Agency Earth Observation (SANSA EO) site. HartRAO is also a full member of the EVN.



Fig. 1 Please join us for the 9th IVS General Meeting to be held in South Africa in March 2016!

2 Technical Parameters of the 15-m and 26-m Telescopes of HartRAO

Table 1 contains the technical parameters of the HartRAO 15-m and 26-m radio telescopes, while Table 2 and Table 3 contain technical parameters of the HartRAO 15-m and 26-m receivers, respectively. The current data acquisition systems consist of a DBBC terminal and a Mark 5B+ recorder for both the 15-m and the 26-m antennas. A Mark 5B and a Mark 5C recorder are used for e-transfer of data and conditioning and testing of disk packs. Three hydrogen masers are available for use, namely the EFOS-28,

which is currently employed for VLBI on the 15-m antenna, as well as two spares – iMaser 72, currently employed on the 26-m antenna, and the resuscitated EFOS-6.

Table 1 Antenna parameters.

Parameter	Hart15M	HartRAO
Owner and operating agency	HartRAO	HartRAO
Year of construction	2007	1961
Radio telescope mount	Az-El	Offset equatorial
Receiving feed	Prime focus	Cassegrain
Diameter of main reflector d	15 m	25.914 m
Focal length f	7.5 m	10.886 m
Focal ratio f/d	0.5	0.42
Surface error of reflector (RMS)	1.6 mm	0.5 mm
Short wavelength limit	2 cm	1.3 cm
Pointing resolution	0.001°	0.001°
Pointing repeatability	0.004°	0.004°
Slew rate on each axis	Az: 2° s ⁻¹ El: 1° s ⁻¹	HA: 0.5° s ⁻¹ Dec: 0.5° s ⁻¹

Table 2 Parameters of the 15-m co-axial receiver.

Parameter	X-band	S-band
Feeds	stepped horn	wide-angle corrugated horn
Amplifier type	cryo HEMT	cryo HEMT
$T_{\text{sys}} (K)$	40	42
$S_{\text{SEFD}} (Jy)$	1400	1050
PSS (Jy/K)	35	25
3 dB beamwidth (°)	0.16	0.57

Table 3 Parameters of the 26-m receiver (degraded performance due to dichroic reflector being used for simultaneous S-X VLBI).

Parameter	X-band	S-band
Feeds	dual CP conical	dual CP conical
Amplifier type	cryo HEMT	cryo HEMT
$T_{\text{sys}} (K)$	52	40
$S_{\text{SEFD}} (Jy)$	849	1190
PSS (Jy/K)	16.3	29.8
3 dB beamwidth (°)	0.096	0.418

3 Current Status

During 2014, the 15-m antenna took over much of the 26 m's workload with the number of sessions in-

volving HART15M more than doubling the previous year's number. The 15-m antenna joined in its first OHIG sessions in February and successfully participated in its first CONT campaign during May 2014, taking over from the 26-m antenna, which was involved in previous CONT02, CONT05, CONT08, and CONT11 campaigns. During September 2014, the 15-m antenna also participated in its second AUSTRAL-CONT campaign. In contrast to the increased number of sessions run on the 15-m antenna, the 26 m's workload nearly halved compared to that of 2013. Eight dual experiments, four R1s, and four AUSTs, with both the 15-m and 26-m antennas observing, were performed during the year. On the 4th of August 2014 at 10:22:33 UT during one of these dual sessions, R1647, the Orkney earthquake occurred approximately 100 km from HartRAO, registering a magnitude of 5.5 on the Richter scale. The 15-m and 26-m antennas each also participated in two Chinese Lunar Lander Chang'E-3 RD/OCEL sessions during 2014. Geodetic VLBI data for all but the RDV sessions were e-transferred to the correlators. Telescope time allocation for geodetic VLBI in 2014 consisted of 122 sessions for the 15-m and 31 sessions for the 26-m antenna (Table 4). On the 23rd of April 2014 the 22 GHz receiver was installed on the 26-m antenna. It will be used for astrometric VLBI to help improve the ICRF. During observation of the bright AGN J1427-4206 with the HartRAO 26-m, Hobart 26-m, and Tidbinbilla 70-m antennas during a 24-hour astrometric VLBI on 4-5 May, interference fringes were detected. The process of procuring the VGOS antenna started in 2014 with the granting of exemption from an EIA, the completion of a DC resistivity ground survey, and an RFI study showing no activity in the requisite bands. During April 2014, Ludwig Combrinck installed a seismometer and accelerometer on Marion Island, repaired the DORIS system, surveyed it in and tied it to the GNSS receiver with GPS. As part of the development of the new Lunar Laser Ranger, the laser systems from Ekspla were commissioned from 18-22 November 2014.

4 Personnel

On the 14th of August 2014 our director, Dr. Mike Gaylard, passed away. Space geodesy program leader, Professor Ludwig Combrinck, is

Table 4 Geodetic VLBI experiments in which HartRAO participated during 2014.

Experiment	No. of sessions on 15 m	No. of sessions on 26 m
R1	36	5
AUST	26	7
AUST14	17	0
CONT14	15	0
R4	15	0
RD	7	5
OHIG	4	2
RDV	2	1
CRDS	0	6
CRF	0	3
T2	0	2
Total	122	31

currently HartRAO's acting director. Table 5 lists the HartRAO station staff involved in geodetic VLBI. Jonathan Quick (VLBI friend) provides technical support for the Field System as well as for hardware problems. Philip Mey, project manager of the VGOS radio telescope, has joined the geodetic VLBI team as a trainee operator at the end of 2014. Ludwig Combrinck, Aletha de Witt, Denise Dale, Sayan Basu, Glenda Coetzer, and Marisa Nickola attended the 8th IVS General Meeting in Shanghai, China held 2-7 May 2014, and all contributed with presentations or posters. Ludwig invited the IVS family to join us under African skies for the 9th IVS General Meeting to be held in South Africa in March 2016. Alet represented HartRAO in the IAU's ICRF-3 working group during this meeting and the subsequent 'REFAG, Symposium 2014 on Reference Frames for Applications in Geosciences' held in Luxembourg in October 2014. Philip and Ludwig visited the Wettzell Observatory in Germany during September 2014 to learn about the VGOS Twin Telescope and discuss antenna design.

5 Future Plans

200 sessions are scheduled for 2015, 30 of those on the 26-m antenna with the remainder having been allocated to the 15 m. Hart15M will participate in AUSTRAL-CONT campaigns during February and June 2015. VGOS activities planned for 2015 include core drilling to determine the depth to bedrock, digging of trenches and laying of cables, award of tender for construction and laying of foundation, and the

Table 5 Staff supporting geodetic VLBI at HartRAO.

Name	Function	Program
L. Combrinck	Program Leader	Geodesy
J. Quick	Hardware/Software	Astronomy
R. Botha	Operator	Geodesy
J. Grobler	Operator	Technical
P. Mey	Operator	Geodesy
R. Myataza	Operator	Technical
M. Nickola	Logistics/Operations	Geodesy
P. Stronkhorst	Operator	Technical
C. Zondi	Operator	Technical

subsequent construction of the VGOS antenna. Work on the Lunar Laser Ranger (LLR) project will continue during 2015. Alet will attend the 22nd Working Meeting of the European VLBI Group for Geodesy and Astrometry in Saõ Miguel, Azores in May 2015 as well as the 2015 IAU General Assembly in Honolulu, Hawaii in August 2015, representing HartRAO at the IAU's ICRF-3 working group meetings. Preparations for hosting the 9th IVS General Meeting in March 2016 will also be a priority during 2015.

Acknowledgements

HartRAO is a National facility operating under the auspices of the National Research Foundation (NRF), South Africa. The Space Geodesy Programme is an integrated program, combining VLBI, SLR, and GNSS, and it is active in several collaborative projects with GSFC, JPL, and GFZ (Potsdam) as well as numerous local institutes. Collaboration also includes CNES/GRGS/OCA and the ILRS community in a Lunar Laser Ranger (LLR) project with local support from the University of Pretoria and the National Laser Centre (CSIR), among others. General information as well as news and progress on geodesy and related activities can be found at <http://geodesy.hartrao.ac.za/>.



Fig. 2 Hamba kahle, Mike.



Fig. 5 Pieter, Alet, Jon and Keith getting ready for K-band's welcoming celebration — Hello Kitty!



Fig. 3 The 15 m antenna in action during CONT14.



Fig. 6 Philip's rig for measuring RFI at the proposed VGOS site.



Fig. 4 The 22 GHz receiver, installed on the 26 m on 23 April 2014.



Fig. 7 Seismometer installation on Marion Island with DORIS hut in background.